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Yield Determinants of a Promising Mungbean Line under Various Planting Densities

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ABSTRAK

Satu ujikaji telah dijalankan dari September hingga November, 1992 di Regional Agricultural Research Station (RARS), Ishurdi, Bangladesh bagi menilai prestasi pertumbuhan kacang hijau (cv. Mosk-1) dalam berbagai kepadatan populasi pokok. Rawatan yang diuji terdiri dari 20×10^4, 30×10^4, 40×10^4, 50×10^4, 60×10^4 *dan* 70×10^4 *pokok* ha^{-1}. *Kepadatan populasi pokok yang terendah menunjukkan jumlah bahan kering (JBK) pokok*$^{-1}$, *kadar pertumbuhan tanaman (KPT) dan lengai pokok*$^{-1}$ *yang tertinggi sementara kepadatan yang lebih tinggi (i.e., 50 atau 60 pokok* m^{-2}*) member hasil bijiran tertinggi (> 1.3 t* ha^{-1}*) dan lebih JBK per unit keluaran. JBK, bahan kering daun dan lengai berkolerasi secara positif dengan hasil bijirin. Sebaliknya bahan kering batang dan tangkai daun berkolerasi secara negatif dengan hasil bijirin.*

ABSTRACT

A field experiment was conducted during September to November, 1992 at the Regional Agricultural Reseach Station (RARS), Ishurdi, Bangladesh, to evaluate the growth performance of a mungbean line (cv. Mosk-1) under varying plant population densities. The treatments consisted of 20×10^4, 30×10^4, 40×10^4, 50×10^4, 60×10^4 *and* 70×10^4 *plants* ha^{-1}. *The lowest plant population density recorded the highest total dry matter (TDM) plant*$^{-1}$, *crop growth rate (CGR), and pods plant*$^{-1}$, *while higher plant population (i.e. 50 or 60 plants* m^{-2}*) produced the highest grain yield (> 1.30 t* ha^{-1}*) and higher TDM per unit area. TDM, leaf and pod dry matter were positively correlated with grain yield. In contrast, stem and petiole dry matter showed negative correlation with grain yield.*

INTRODUCTION

Yield of mungbean (*Vigna radiata* (L) Wilczek) is generally low due to inherent low yield potential of the existing cultivars. Besides short growth duration, particularly the slow rate of dry matter accumulation prior to flowering, unfavourable canopy structure, nonresponsiveness to fertilizer application, etc. are limiting factors for low productivity (Hamid *et al.*, 1991). Planting density is one of the principal factors affecting the grain yield of leguminous plants (Nakaseko *et al.*, 1979; Graham and Chatel, 1983). Optimum plant density has major and direct effects on vegetative growth and seed yields of legumes (Singh and Yadav, 1978; Rowden *et al.*, 1981; Herbart and Baggerman, 1983). Leaf area index (LAI) is an important determinant of dry matter production and, hence, yield. Higher LAI value can usually be achieved by increasing plant population density and nutritional supply (Kuo *et al.*, 1978). However, studies on growth pattern and understanding the various physiological processes under variable plant population densities in relation to seed yield of mungbean to evaluate the physiological basis of yield variations in mungbean, and to find the optimum plant population density required to achieve higher yield.

MATERIALS AND METHODS

A field experiment was conducted at the Regional Agricultural Research Station (RARS), Ishurdi, Bangladesh, during September to November, 1992, where the soil is a sandy loam with pH 7.0-7.5. The cultivar used was Mosk-1, a promising mungbean line. The treatments were different planting distances: i) 25 x 20 cm, ii) 25 x 13.2 cm, iii) 25 x 10 cm, iv) 20 x 10 cm, v) 20 x 8.33 cm, vi) 20 x 7.14 cm corresponding to 20 x 10^4, 30 x 10^4, 40 x 10^4, 50 x 10^4, 60 x 10^4, 70 x 10^4 plants ha^{-1}. The sowing was done in the first week of September, 1992. The experiment was laid out in a randomized complete block design with four replications. After emergence of the crop, ten randomly selected plants from each plot were taken at eight day intervals until maturity for the determination of growth parameters. Data on yield attributes were recorded from ten randomly selected plants from each plot. Grain yield was assessed by harvesting an area of 16 m^2 from the centre of each plot and converting the result into tons per hectare (t ha^{-1}). Collected data were analyzed statistically by using analysis of variance and Duncan's Multiple Range Test at 5% level of probability was applied to compare differences among the treatment means (Gomez and Gomez, 1984).

RESULTS

Dry Matter Accumulation

TDM accumulation showed significant variation among the treatment variables. The highest and lowest TDM per plant were recorded from the lowest and highest plant population densities respectively. In contrast, TDM per unit area was inversely related with TDM per plant. The rate of dry matter production was similar in all plant population densities up to 10 days after emergence (DAE) after which it differed significantly until harvest (Fig. 1). Dry matter production slowed a little before the pre-flowering stage (30 DAE) but thereafter a sharp increase in dry matter production was observed up to pod development stage (50 DAE), when all treatments recorded higher dry matter production indicating attainment of physiological maturity.

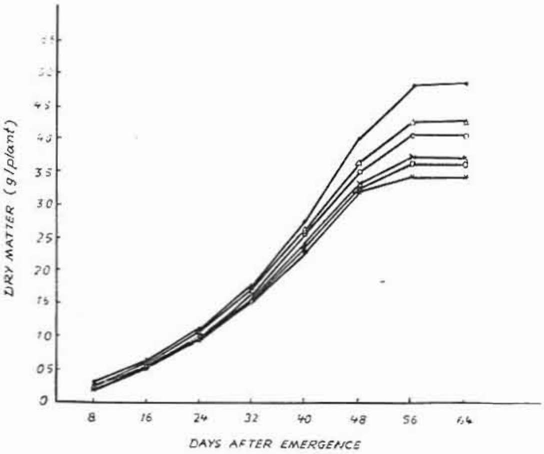

Fig. 1: Influence of plant population density of mungbean on the dry matter accumulation over time

• *20* x *10^4 plants/ha* Δ *30* x *10^4 plants/ha*
0 *40* x *10^4 plants/ha* x *50* x *10^4 plants/ha*
□ *60* x *104 plants/ha* * *70* x *10^4 plants/ha*

Partitioning of Dry Matter

Table 1 shows the relative contribution of dry matter accumulation. At the vegetative phase the leaf accounted for 50-58%, petiole 12-16% and the stem 30-34% of TDM accumulation. On the other hand, at the reproductive phase the stem accounted for 14-18%, reproductive organs 34-38%, and the leaves and petioles 34-38% and 10-14% respectively. For plant population densities of 50 x 10^4 and 60 x 10^4 plants ha^{-1} the photosynthetic organs, i.e. leaves and petioles, contributed 34-38% and 10-14% to TDM respectively. For plant population densities of 50 x 10^4 and 60 x 10^4 plants ha^{-1} the photosynthetic organs at both vegetative and reproductive phases contributed more and the reproductive organ slightly more than other plant densities.

Crop Growth Rate (CGR)

CGR was significantly affected by variation in plant population densities. The highest and lowest CGR were obtained from the lowest and highest plant densities respectively (Fig. 2). Crop growth rate was slow during the early vegetative phase up to the pre-flowering stage (30 DAE). Thereafter, it increased sharply with the growth of the plant. The maximum CGR was recorded at pod development stage (50 DAE) in all treatments, after which it declined rapidly.

TABLE 1
Relative contribution of different plant components as percentage of total dry matter at the vegetative and reproductive phases of mungbean

Plant ha^{-1}	Vegetative phase			Reproductive phase			
	Stem	Leaf	Petiole	Stem	Leaf	Petiole	R.O.*
20 x 10^4	34	50	16	18	34	14	34
30 x 10^4	32	52	16	18	34	14	34
40 x 10^4	31	55	14	16	36	12	36
50 x 10^4	31	57	12	14	38	10	38
60 x 10^4	30	58	12	15	37	11	37
70 x 10^4	31	56	13	16	36	12	36

* Reproductive organ

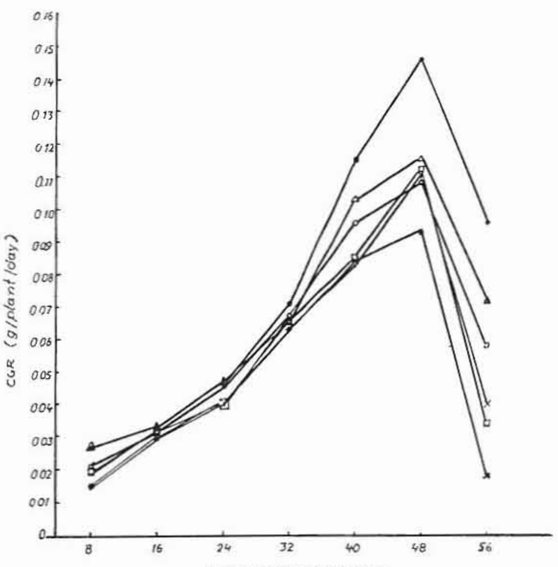

Fig. 2: Influence of plant population density on crop growth rate (CGR) of mungbean over time

• *20 x 10^4 plants/ha*	Δ *30 x 10^4 plants/ha*
0 *40 x 10^4 plants/ha*	x *50 x 10^4 plants/ha*
□ *60 x 104 plants/ha*	* *70 x 10^4 plants/ha*

Grain Yield and Yield Attributes

Grain yield and pods per plant were significantly affected due to variation in plant densities (Table 2). The highest yield (1.39 t ha^{-1}) was obtained from 60 x 10^4 plants ha^{-1} and it was statisticallly at par with 50 x 10^4 plant ha^{-1}. The lowest yield (0.77 t ha^{-1}) was obtained from the lowest plant density (20 x 10^4 plant ha^{-1}). Sparse plant population densities, although producing more pods per plant, cannot compensate, and higher yields were recorded in treatments with higher population densities but with less pods per plant. Number of seeds per pod and thousand-seed weight did not show any significant differences. Plant height showed significant variation among the treatment variables. The highest plant height was recorded from the highest plant density, and the lowest plant height from the lowest plant density, and it was statistically at par with 30 x 10^4 plant ha^{-1}.

Harvest index (HI) was significantly affected due to variation in plant densities. The highest HI was obtained from 60 x 10^4 plants ha^{-1} and it was statistically at par with 50 x 10^4 plants ha^{-1}. The lowest HI was obtained from the highest plant population density.

Correlation Between Yield and Other Characters

Correlation analysis (Table 3) showed that pods per plant was positively correlated with stem dry matter (SDM), CGR, and HI, and negatively with plant height (PH), leaf dry matter (LDM), pod dry matter (PDM), TDM, and yield. Plant height showed positive correlation with all traits excepts SDM and CGR. SDM showed strong negative correlation with all traits except pods per plant, SDM and CGR. Similarly, LDM showed positive correlation with all traits except pods per plant, SDM and CGR. CGR showed negative correlation with all traits except pods per plant, SDM and HI. Seed yield was positively correlated with PH, LDM, PDM, TDM, HI and negatively with pods per plant, SDM and CGR.

DISCUSSION

Grain yield per unit area is a function of yield of individual plant times plant density. Per plant yield is governed by number of pods per plant,

TABLE 2
Yield and yield attributes of mungbean under varying levels of plant density

Plant density (plants ha^{-1})	Yield (t ha^{-1})	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt (g)	Plant height (cm)	TDM (t ha^{-1})	HI
20 x 10^4	0.77e	22a	9.0	24.0	35.8c	1.85d	0.42b
30 x 10^4	0.97d	18ab	9.0	24.0	38.7c	2.30c	0.42b
40 x 10^4	1.13c	16abc	8.5	23.8	40.3bc	2.68b	0.42b
50 x 10^4	1.33a	15bc	8.5	23.6	44.5ab	3.00a	0.44a
60 x 10^4	1.39a	13bc	8.3	23.5	45.0ab	3.10a	0.45a
70 x 10^4	1.25b	10c	8.2	23.5	48.7a	3.15a	0.40c

Means followed by the same letter are not significantly different at 0.01 level of significance

TABLE 3
Interrelationships among different traits in mungbean

	PH	SDM	LDM	PDM	TDM	CGR	Y	HI
PP	-0.97**	0.64**	-0.64**	-0.64**	-0.95**	0.86**	-0.86**	0.05
PH		-0.72**	0.72**	0.72**	0.95**	-0.72**	0.87**	0.02
SDM			-0.99**	-0.99**	-0.84**	0.60**	-0.91*	0.53**
LDM				0.99*	0.84*	-0.60**	0.91*	0.53*
PDM					0.84**	-0.60**	0.91**	0.53*
TDM						-0.86**	0.97**	0.21
CGR							-0.79**	0.41*
Y								0.44*

PP - Pods plant^{-1}; PH - Plant height; SDM - Stem dry matter; LDM - Leaf dry matter; PDM - Pod dry matter; TSN - Total dry matter; CGR - Crop growth rate; Y - Seed yield

number of seeds per pod and seed size. Both yield and yield attributes were markedly influenced by plant density. Hamid *et al.* (1991) reported that optimum density of mungbean for higher yield should be somewhere in between 50 and 60 plants m^{-2}. They also reported that more widely spaced plants developed more branches but the contribution of secondary and tertiary branches towards grain yield was negligible. Radjit and Adisarwanto (1988) also reported that high plant densities (66 plant m^{-2}) produced significantly increased grain yield in mungbean. In case of closer row spacing, plants develop few branches, most of the pods developing on the main stem.

High dry matter production is one prerequisite for greater productivity in crop plants. In addition, developmental factors affecting the accumulation of dry matter and subsequent partitioning of assimilates are of great importance in determining the final yield in crops (Duncan *et al.*, 1978). Dry matter accumulation after flowering in mungbean greatly influences seed yield, for most of the photosynthate produced at this stage is used for pod and seed development and would be a desirable trait for efficient genotypes. Similar results were reported by Hamid *et al.* (1991). Motior *et al.* (1992) reported that chickpea genotypes having the capability of producing more dry matter in leaf and petiole than stem during both the vegetative and reproductive phases had higher initial crop growth rates, and a rapid and sharp increase in grain development after anthesis, all of which were found to be important characters for higher productivity. Motior *et al.* (1993) also found similar results in lentil. Grain yield may be considered as a function of biomass accumulation and its partitioning to grain (Sinclair and Horie, 1989)

The ultimate partitioning of dry matter between reproductive and vegetative parts is indicated by the harvest index (HI). One of the most fundamental factors affecting this is the capacity to mobilize photosynthate to the plant organs having economic value. A higher proportion of leaf dry matter to be mobilized during the early reproductive phase of development will enhance the harvest index. Measurement of harvest index can help identify and define the translocation capacity, and thereby, help identify varieties with partition potential (Kuo *et al.*, 1978). Harvest index depends on the relative durations of the vegetative and reproductive phases, and during the reproductive phase, the relative partitioning of current assimilate, and the degree of remobilization of stored assimilate to reproductive organs (Lawn, 1989).

The results of correlation between yield and other characters are in partial agreement with the findings of Perigio *et al.* (1989) and AVRDC (1975). Perigio *et al.* (1989) reported that in the case of cultivar differences in mungbean, pods per plant showed positive correlation with seed yield and it is one of the most important yield component character to select any cultivar. AVRDC (1975) reported that yield is positively correlated with pods m^{-2} and they used only 10, 30 and 50 plants m^{-2}. However, in that study pods per plant did not play a positive role and compensate yield due to variable plant densities.

Our study shows that percentage of leaf dry matter (photosynthetic organ), pod dry matter (reproductive organ), total dry matter and harvest index are very important traits for achieving higher yield. The results of the experiment revealed that different growth parameters like CGR and TDM can make a crop more or less productive when grown under variable plant population densities, and that for maximum yield realization of mungbean the optimum plant stand lies between 50 x 10^4 or 60 x 10^4 plant ha^{-1} provided the crop is sown at an optimum time.

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